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# WATER RESOURCES IN SIERRA LEONE

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# WATER RESOURCES IN SIERRA LEONE

BY

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## INTRODUCTION

Sierra Leone is essentially an agricultural country, more than 4/5ths of its population of an estimated 2½ million living in the rural areas. Hence it has few large centres of population, the largest being its capital, Freetown, whose population has been estimated variously as being between 100,000 and 200,000 people.

2. The whole Country lies in the equatorial forest region and is therefore subject to the usual extremes of heavy rainfall and long periods of drought, which are associated with areas similar to the monsoon areas of Asia and the Far East.

3. Rainfall is heaviest in the coastal belt which consists of a narrow pene-plain backed by high mountain ridges which make favourable conditions for heavy rain from moisture laden south-westerly winds from the Atlantic (Fig I). The heaviest rainfall is about 200" per annum on the coast and rainfall decreases as one proceeds inland to about 40" per annum in the extreme north-eastern corner of the Country.

4. Geologically the coastal areas consist of sedimentary deposits of the bullom series overlying igneous rocks. Over the rest of the Country the igneous rocks, in some cases metamorphosed to clays, shales and schists persist - Fig II.

5. Eight main rivers form the principal drainage system of the Country. The Great Scarcies forms the boarder with Guinea on the North-West and is the largest river in the territory. Next are the Little Scarcies, the Rokel or Seli, Gbangbaia, Taia, Sewa, Wanje and the Moa, which in its Northern reaches forms part of the Eastern frontier between Sierra Leone and Guinea - Fig III.

## APPRAISAL OF EXISTING RESOURCES, USES AND REQUIREMENTS AND ALLOCATION TO DIFFERENT USES

### Surface Water

6. Fig III shows the layout of the main drainage system and Table I gives estimated values of run off from this system. In addition to these sources, ample water exists in the rivers of the minor tributary system but these are subject to large variations in seasonal flow so that their use would in many cases involve the construction of dams for impounding water from the rainy season run-off for dry season use.

7. Due to the relatively low population density the use of the main drainage system as centralised sources of urban supply does not at the present time appear practicable.

8. The phenomenon observed in the more industrialised parts of the World that large townships develop along river banks for the usually given reasons of accessibility by water and the proximity of water for use, is not observed in Sierra Leone, for the principal reason that the physical nature of the Country is such that its rivers are

navigable only for a short distance inland from the point of entry into the sea. Therefore, the large rivers, which are the assured sources of a sufficient quantity of water for urban development, are not usable for this purpose without a great expense in aqueducts to convey the water from the rivers to the towns. Often, because of the lack of information on the quantities in the minor drainage system, a large expenditure has been undertaken to provide water from the main drainage systems in the few townships which are now developing.

9. Facilities do not at present exist for collecting and formalising the information necessary for economic use to be made of the Country's resources in surface water. In order that the best use may be made of these, it is of paramount importance that facilities be established for collecting the basic hydrological and meteorological information needed in economic design. The main deterrents to the realisation of such a recording system are the lack of funds and personnel. Preliminary estimates for such a system amount to about £100,000 - a sum about twenty times the total amount which the Government of Sierra Leone has found it possible to expend for this purpose in the past eight years.

10. The usefulness of any water resources survey carried out must be conditioned by knowledge of present populations and a reasonable forecast of population growth, by a clearly defined but flexible plan of overall development, including industrial development, and by the degree of accuracy with which the parameters which affect the stream flow are determined.

11. Since other methods of power development within Sierra Leone would depend on the importation into the Country not only of materials for power generation, but also for the continous importation of materials for the up-keep and maintenance on these units, the economy of the Country would stand to benefit by the utilisation of local material, in this case in the form of harnessed water power for power generation for industrial and urban use. Reliable information on the potential of the surface water is also of prime importance in the planning of irrigation schemes for the production of more food. For these reasons as well as for the use of water as such in supplies to urban communities, it is important that such a network of river gauges be established around the Country on its main and subsidiary drainage system in order that reliable estimates of the yield may be determined.

12. Such recording stations would have to meet requirements which are peculiar to areas similarly placed as Sierra Leone. For instance, the lack of suitably trained personnel to man and reliably observe these gauges make it necessary that they should be self-recording and integrating so that analysis only at a centralised place, manned by the few trained people available, would be necessary.

13. Detailed studies of the percolation and other physical factors can commence at a subsequent date to the actual measurement of stream flow.

14. The measurement of flows from selected streams in the subsidiary drainage system, which will constitute the main source of surface water for urban use, can be carried out simultaneously with the measurement of flows from the main drainage network.

15. The work outlined above can best be done in a hydrological section of the Public Works Department manned by two hydrologists.

Ground Water.

16. No estimate of underground water sources has been made. Percussion equipment capable of drilling 6" and 8" boreholes to depths of 800 is now on order and it is hoped, whilst installing water supplies in a few places with the help of this equipment, to collect enough information to enable a preliminary assessment of underground water resources to be made. In the context of the observation that large townships do not grow on river banks of Sierra Leone, it is important that wherever possible such ground water reserves as exist should be developed to the fullest before recourse is had to the more expensive alternative of transporting surface water from long distance.

17. Due to the largely forest nature of the Country, preliminary surveys connected with borehole location and levels are very arduous and time-consuming. It is hoped that help will be available in utilising the aerial photographs which now exist for most of the country to reduce the time and labour involved in this aspect of the work; however, before this can be done, a lot more knowledge in the geological and emological

photo-interpretation of the aerial photographs and more ground control are necessary. It is necessary that a technique be developed with a high degree of accuracy for locating possible sources of ground water from these aerial photographic studies aided by adequate ground control.

18. There is not in the Public Works Department, personnel trained in operating borehole drilling equipment and it is planned to recruit staff from overseas for this purpose in the first instance. The early stages of prospecting work for using this equipment will be carried out entirely without the help of the aerial photographs, but the result obtained from the first few boreholes, with detailed geological studies of the area co-ordinated with the aerial photographs, should give enough pointers for locating future boreholes. Such information as is available from similar studies carried out elsewhere, would be of great value to the Government of Sierra Leone.

19. The use of waters in plutonic reservoirs has not been contemplated. It is hoped that boreholes of medium reach would in these early stages be sufficient for the needs of most centres of population. In a particular area of Sierra Leone, namely in Bonthe Island, preliminary drilling has shown that water reservoirs are available within 200 ft. of the ground surface, but difficulty is contemplated that with draw-off at the rate of consumption, salt-water intrusion is likely. Some thought is being given to the problem now of providing suitable safeguards against the expected advance of the salt-water interface.

20. In areas removed from sources of surface water, shallow wells have been dug and have been in use by indigenous communities. The hazards and limitations of the shallow well are manifold.

Main Water Uses.

21. In the present state of development of the Country, the main water uses are domestic and urban, while there is little doubt that with the increasing trend towards industrialisation, there will be an increasing use of water for industrial purposes. At present less than 5% of the total water consumed over the Country is applied to those uses which are described as industrial in other countries. More than 90% of the water supply for urban and domestic purposes is obtained from surface sources by impounding where necessary the surface run-off from the main and subsidiary drainage systems of the Country.

22. It is a paradox that on the coastal plain where the greatest precipitation occurs, the greatest want for water in periods of no precipitation is felt. Historically this is due to the rapid growth of urbanisation in the Western coastal plains - at a rate exceeding any which could have been forecast when the urban water supply system for the capital, Freetown, was first installed more than 70 years ago.

23. The use of water for urban and domestic purposes will continue at a rate faster than was hitherto encountered for the per capita consumption will be at an increasing rate by a population which is itself increasing. An appraisal, therefore, of the water needs must be based on forecast of future requirements. Because of the large number of unpredictables which are associated with such a forecast, it is not considered good practice to forecast for a period exceeding fifteen years.

24. On this basis, the needs of the urban communities are as shown in Table 2. This includes a certain provision for an increased consumption for industrial purposes - Fig IV.

25. In rural communities there is a tendency for central Government to participate in the development of rural housing schemes tending to alter the consumption pattern of rural communities. Present thinking on the design of rural communities leads to a large land allocation per house, which in turn is reflected in a high per capita consumption of treated water. In a non-directed growth of rural communities the water needs would be divided into two types:-

(a) treated water for human and animal consumption and

(b) raw water for irrigation and other farm purposes.

Hence, one significant result of Government participation in rural and sub-urban housing schemes is that the cost of such schemes as reflected in the water supply costs is higher than would have been the case otherwise.

## A.1.1.2 - ORGANISATION OF METEOROLOGICAL AND HYDROLOGICAL SERVICES

26. Government maintains a Meteorological Department but not a Hydrological one. Hydrological information is collected principally by the Public Works Department, the Land Reclamation Section of the Department of Agriculture and to a small, but increasing extent, by the University College of Sierra Leone.

### Rainfall

27. Rainfall records are collected in 22 stations by the Meteorological Department and agents of this Department. In one of these 22 stations there is a recording rain gauge from which storm intensity data can be evaluated. All other sources are daily observation stations and only the total precipitation in a 24-hour period is obtained, - Fig V. The need for storm intensity observation in more than one station must be obvious in view of the fact that the relationship between the average rainfall in the wettest and driest parts of the Country is about 5 to 1.

28. As most schemes in use at present have surface water sources involving impounding, the design of spillways, which must be conditioned by storm intensities, is at present based on a conjectural co-relation of average rainfall in the area of the project with that at the station in which there is a recording rain gauge. The fact that no catastrophic results have followed this method of design is not to be interpreted as establishing the validity of the process, but is due to a conscious over-designing - a process which is uneconomical and undesireable in a country which must husband its viable resources.

### Evapo-Transpiration

29. There is little literature available on the relative percentages of precipitation which are disposed of by evaporation, transpiration, percolation and run-off. Again the proportions of these are determined by conjecture in any one scheme with a strong bias towards conservative estimation. Studies (2) carried out at Lungi Airport, near Freetown, on a surface evaporimeter and applying Penman's formula, show evaporation in inches to be as tabulated in Table 3. Transpiration studies have not been carried out within Sierra Leone to an extent which would give explicit results. The need for detailed studies in this area as an aid to the economic design of water supplies cannot be over-stressed.

### Stream Flow Studies

30. The Public Works Department carries out ad hoc studies of stream flow in connection with all water supply schemes. There is, as such, no network of stream flow observation stations over the Country, although the desirability of such a network in order to establish the potential of the available sources is recognised (Para. 6 - 13). None of the rivers forming the main drainage pattern of the Country have been studied in detail. Various estimates of seasonal flow from sources have been given, the most recent of which gives estimates of flow as one-third the precipitation. Such an approximation has led to the estimated flows shown in Table 1 (1).

31. A particular problem associated with stream flow studies arises when it is proposed to instal a new water supply scheme in a township using one of the tributaries of the main drainage system. In such cases Public Health and Political requirements demand that the scheme be installed after only one dry season observation of the flow at source. In such cases it is sometimes not practicable to assess the degree of confidence which is applicable to the reliable yield assumed and such a procedure almost always leads to very conservative and probably uneconomic design.

32. In some of the existing meteorological stations rainfall observations have continued for more than 30 years so that it is now possible for the records to be analysed and a pattern of the rainfall described. The lack of a hydrologist and the pressing demands of other work from trained staff have not made such a study possible. In this respect some help can be given with the recruitment of a trained hydrologist to be attached to the Public Works Department to help make the greatest use of the information already assembled. Such an expert would need to be in the Department for a period of approximately two years.

33. In addition to such an expert, two other trained hydrologists would be needed to organise the location of further rain gauges, in the areas where they are most likely to be needed. These rain gauges, being of the recording type, would give further information on the rainfall pattern from which interim results would be assembled. If the organisation of stream flow records mentioned earlier is undertaken at the same time, further useful information would be obtained by relating stream flow with such rainfall measurement as are made.

34. Simultaneously with stream flow and rainflow observations an effort could be made to determine local values for the variants associated with evapo- transpiration, either by applying one of the established procedures used in other areas, or by independently determining the procedure which would be applicable to this area. Information derived from such methods would provide the material which is necessary to ensure that the best use is made of the water available and funds allocated for its development.


1. WOODACRE B. - GOVERNMENT METEOROLOGIST, PRIVATE COMMUNICATION SEPTEMBER, 1961.

2. VORM W. LAHMEYER & CO. - "HYDRO-ELECTRIC SCHEMES IN SIERRA LEONE" - 1961.

# SIERRA LEONE

## MAIN DRAINAGE.
## CHART OF RUNOFFS.

Table 1.

| NAME OF RIVER. | AT. | Annual mean. | | | Max. monthly mean. | Floodwater. |
|---|---|---|---|---|---|---|
| | | Average year cuft/s | Net year cuft/s | Dry year. cuft/s | cuft/s | cuft/s. |
| Great Scarcies | Kychom | Not available | Not available | Not available | Not available | Not available. |
| Little Scarcies | Mange. | 17,597 | 21,413 | 13,993 | 57,243 | 173,145. |
| Rokel | Rokel | 6,926 | 8,375 | 5,795 | 24,205 | 74,205. |
| Gbangbaia | Moselolo | 18,400 | 22,200 | 15,400 | 64,500 | 197,500. |
| Jong | Matru | 2,260 | 2,740 | 1,895 | 7,900 | 24,200 |
| Sewa | Sumbuya | 4,200 | 5,100 | 3,500 | 1,470 | 4,520. |
| Waanje | Pujehun | 26,600 | 32,200 | 22,900 | 92,500 | 283,000 |
| Moa | Sulima. | 3,600 | 4,400 | 3,020 | 12,400 | 38,300. |
| Mano | Mano Salija. | 55,000 | 67,700 | 46,000 | 194,000 | 595,000 |
| | | | | | | |
| | | | | | | |
| | | | | | | |

# SIERRA LEONE

## PROJECTED URBAN WATER SUPPLIES

TABLE 2.

| TOWNSHIP | PRESENT | | | FUTURE 1975 | | |
|---|---|---|---|---|---|---|
| | POPULATION | PER CAPITA DEMAND | TOTAL DAILY DEMAND | POPULATION | PER CAPITA DEMAND | TOTAL DAILY DEMAND. |
| SEGBWEMA | 6000 | 15 | 90.000 | 20,000 | 20 | 400,000 |
| KABALA | 6000 | " | 90.000 | 20 000 | " | 400 000 |
| JAIAMA NIMI KORO | 6 000 | " | 90,000 | 12 000 | " | 240 000 |
| YENGEMA | 2,000 | " | 30,000 | 8 000 | " | 160 000 |
| MAMBOLO | 4 000 | " | 60,000 | 10 000 | " | 200 000 |
| MATTRU | 6000 | " | 90.000 | 15 000 | " | 300 000 |
| SUMBUYA | 5000 | " | 75.000 | 10.000 | " | 200.000 |
| KASSIRI-KYCHOM | 4 000 | " | 60.000 | 8.000 | " | 160.000 |
| BLAMA | 5000 | " | 75.000 | 10 000 | " | 200.000 |
| MAKALI | 2000 | " | 30 000 | 5.000 | " | 100.000 |
| POTORU | 2000 | " | 30 000 | 6,000 | " | 120.000 |
| SONGO | 2000 | " | 30 000 | 4.000 | " | 80 000 |
| MATEBOI | 2000 | " | 30 000 | 4,000 | " | 80 000 |
| BATKANU | 4000 | " | 60 000 | 8,000 | " | 160.000 |
| MANO | 5000 | " | 75.000 | 8,000 | " | 160.000 |
| ROTIFUNK | 6000 | " | 90,000 | 10,000 | " | 200 000 |
| GBANGBATOK | 2000 | " | 30,000 | 8.000 | " | 160 000 |
| JIMMI GBAGBO | 2000 | " | 30,000 | 4 000 | " | 80 000 |
| KAMAKWIE | 6000 | " | 90.000 | 15 000 | " | 300.000 |
| BONTHE | 6000 | " | 90,000 | 8000 | " | 160.000 |
| TIHUN | 2000 | " | 30,000 | 5000 | " | 100,000 |
| | | | | | | |



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## SIERRA LEONE EVAPORATION LUNGI 1950-1959
## TABLE 3

| MONTH \ YEAR | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | MEAN MONTHLY EVAPORATION INCHES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JANUARY | 5·9 | 5·9 | 4·6 | 4·3 | 5·7 | 6·1 | 5·7 | 5·6 | 5·7 | 5·0 | 5·5 |
| FEBRUARY | 5·8 | 5·8 | 6·6 | 6·0 | 5·8 | 6·4 | 5·8 | 6·0 | 5·7 | 5·7 | 6·0 |
| MARCH | 6·3 | 7·1 | 7·0 | 7·7 | 7·0 | 6·7 | 7·1 | 6·8 | 7·0 | 6·5 | 6·9 |
| APRIL | 6·9 | 7·0 | 7·0 | 7·1 | 6·1 | 6·0 | 6·9 | 6·9 | 6·1 | 7·1 | 6·7 |
| MAY | 5·6 | 5·4 | 6·3 | 6·3 | 6·0 | 6·0 | 6·3 | 6·1 | 5·3 | 5·4 | 5·9 |
| JUNE | 5·4 | 5·1 | 5·3 | 4·4 | 4·4 | 4·7 | 4·8 | 5·0 | 4·6 | 5·0 | 4·9 |
| JULY | 3·7 | 4·3 | 3·9 | 4·2 | 3·7 | 4·0 | 3·5 | 3·7 | 3·7 | 3·7 | 3·8 |
| AUGUST | 3·5 | 3·5 | 3·4 | 3·9 | 3·3 | 3·8 | 3·7 | 4·3 | 3·5 | 3·9 | 3·7 |
| SEPTEMBER | 4·1 | 4·6 | 4·6 | 4·6 | 4·3 | 3·9 | 4·5 | 4·1 | 3·9 | 4·1 | 4·3 |
| OCTOBER | 5·1 | 4·6 | 5·9 | 5·0 | 5·2 | 5·0 | 5·5 | 4·8 | 5·1 | 5·3 | 5·1 |
| NOVEMBER | 4·7 | 4·8 | 4·8 | 5·2 | 4·7 | 5·5 | 5·0 | 5·0 | 4·4 | 5·0 | 4·9 |
| DECEMBER | 5·4 | 5·4 | 5·0 | 4·6 | 5·0 | 4·9 | 4·5 | 5·3 | 4·8 | 5·3 | 5·0 |
| TOTAL | 62·4 | 63·5 | 64·4 | 63·6 | 61·2 | 63·0 | 63·3 | 63·6 | 58·8 | 62·0 | MEAN YEARLY 62·7 |

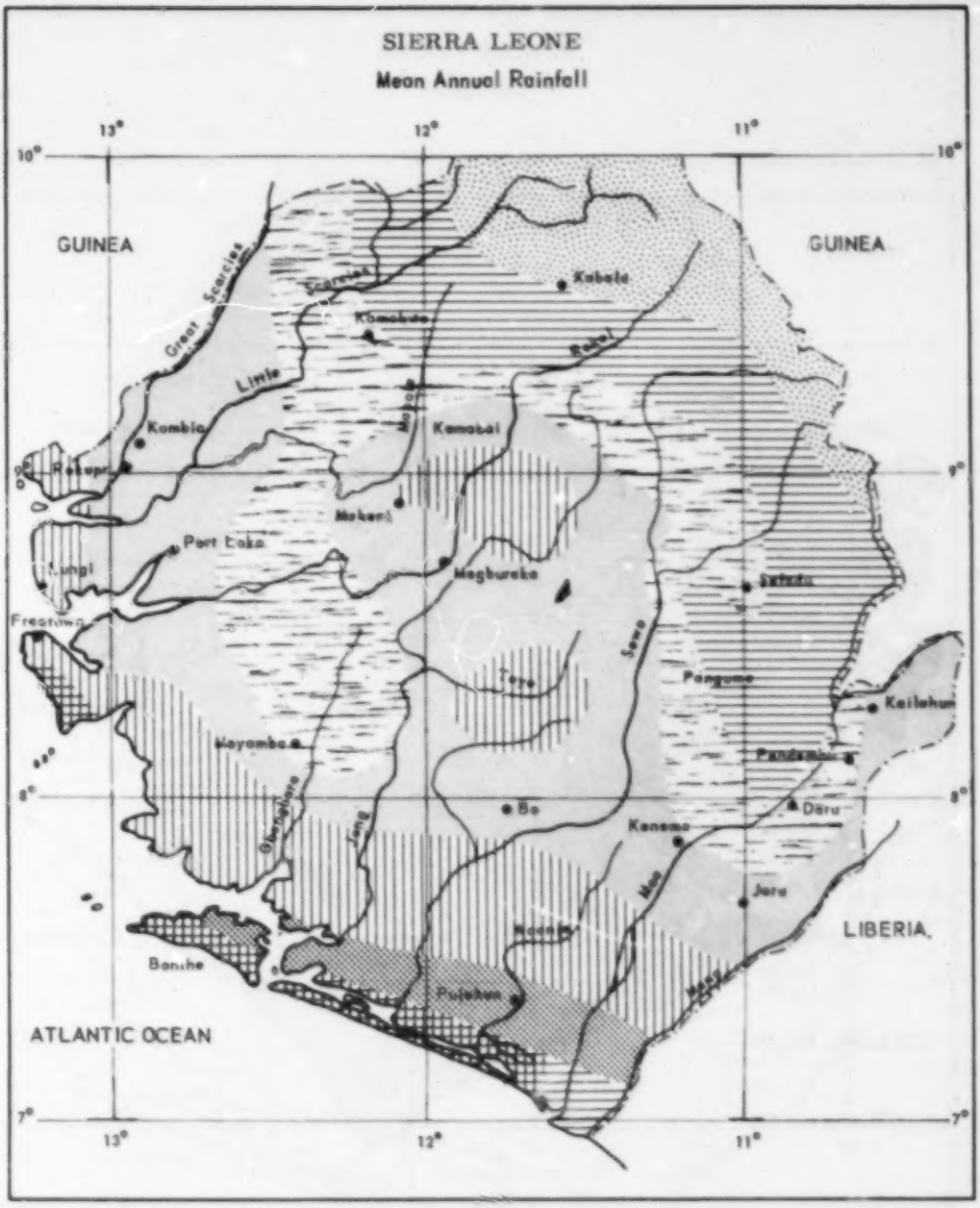


Fig. 1

| | |
|---|---|
| 160 | 100-110 |
| 140-160 | 90-100 |
| 120-140 | 80-90 |
| 110-120 | |

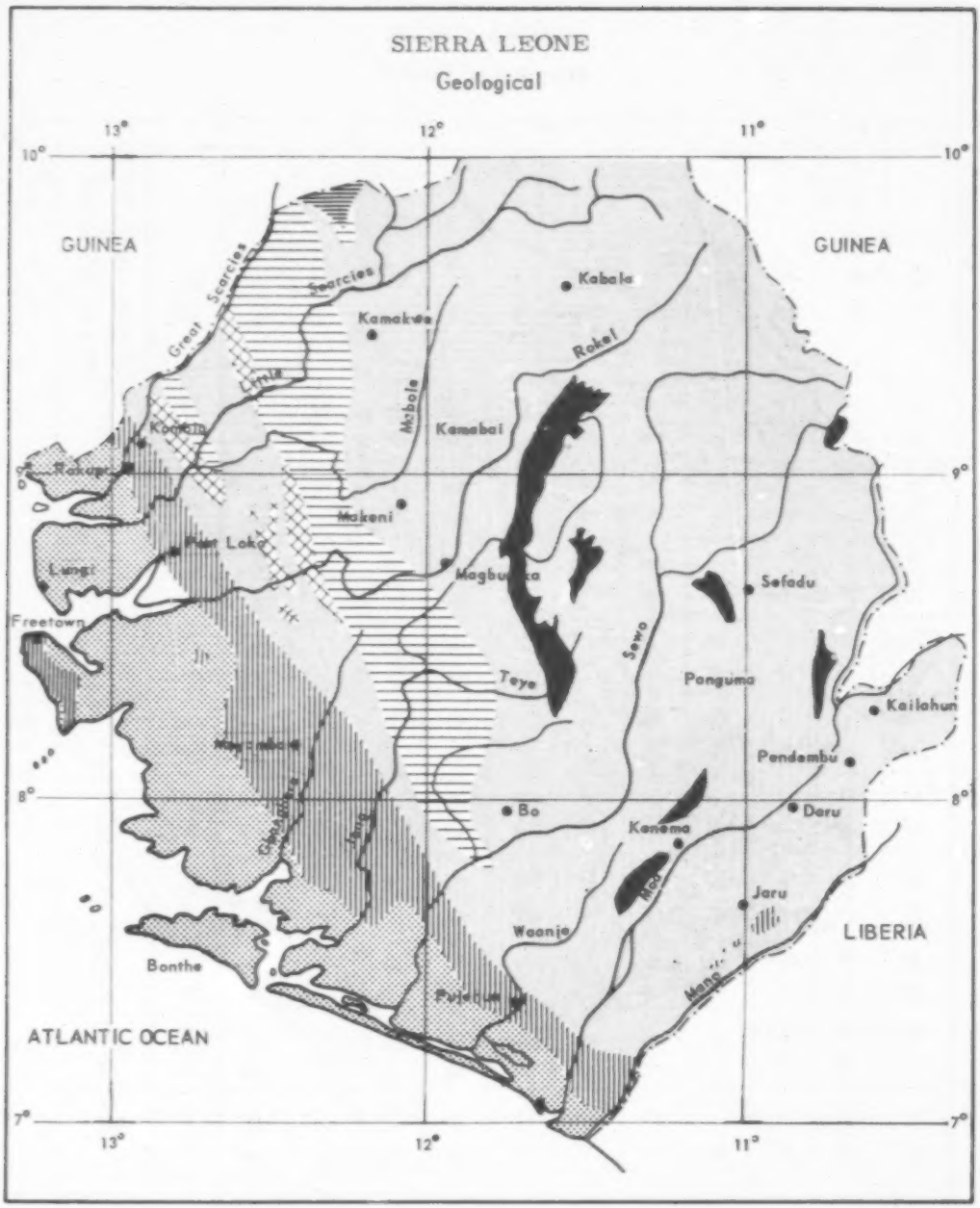
SIERRA LEONE
Geological
13°
12°
11°
10°
9°
8°
7°
GUINEA
GUINEA
LIBERIA
ATLANTIC OCEAN
Great Scarcies
Scarcies
Little
Mabole
Rokel
Kabala
Kamakwie
Kamabai
Koinadugu
Rokupr
Makeni
Port Loko
Lungi
Freetown
Magburaka
Sefadu
Sewa
Taye
Panguma
Kailahun
Pendembu
Bo
Kenema
Daru
Jaru
Waanje
Bonthe
Pujehun
Mano
Bullom Series
Saionya Scarp Series
Rokel River Series
Marampa Schists
Kambui Schists
Kasila Series
Norite and Gabbro
Granite

Fig. 2

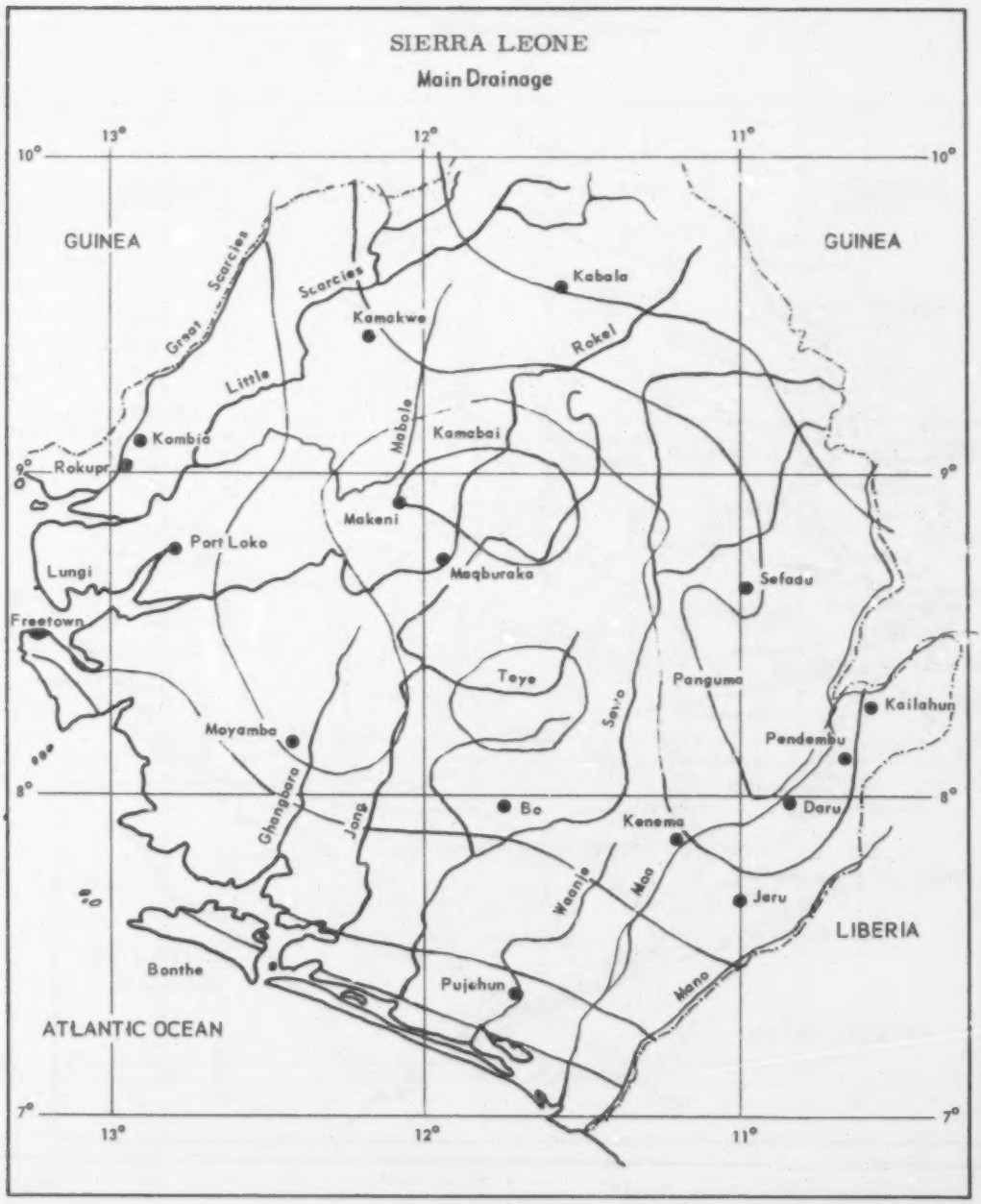
SIERRA LEONE
Main Drainage
13°
12°
11°
10°
9°
8°
7°
GUINEA
GUINEA
LIBERIA
ATLANTIC OCEAN
Great Scarcies
Scarcies
Little
Rokel
Mabole
Kabala
Kamakwe
Kambia
Rokupr
Kamabai
Makeni
Port Loko
Lungi
Freetown
Maqburaka
Sefadu
Teye
Panguma
Sewa
Kailahun
Moyamba
Pendembu
Ghangbara
Jong
Bo
Daru
Kenema
Waanje
Moa
Jeru
Bonthe
Pujehun
Mano

Fig. 3

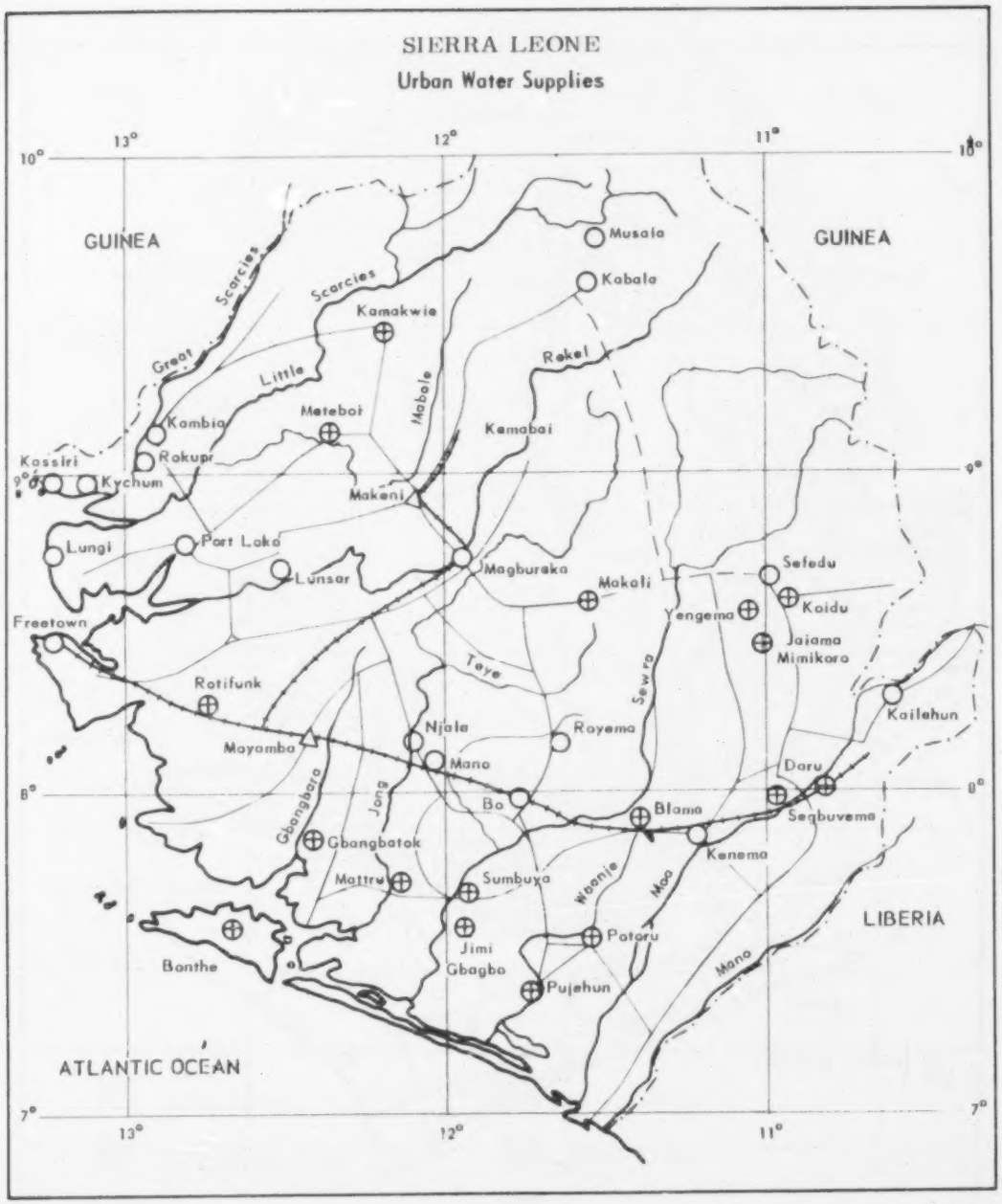


Fig. 4

○ Now Available ⊕ Under Investigation △ Under Construction

Fig. 5

○ Rainfall △ Synoptic ● Climatological

127 E - Oct.1962 - 1,600